Highway Bridge Pier

Column Repair

Using AQUAPREG® 22-71
GLASS COMPOSITE SYSTEM

Bridge over Moyie River
Copeland-Eastport Highway

Idaho Transportation Department
District #1

Report No.  AIR LOGISTICS CORP. 07-31-01

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Introduction

The Idaho Transportation Department, District #1, effected repairs on the Bridge Over Moyie River. See map insert for exact location.

The bridge was built in 1932. The repair described in this report is a structural rehabilitation necessary to prevent the bridge from being weight posted.

IDAHO TRANSPORTATION DEPARTMENT elected to use Aquawrap® 22-71 Concrete Repair System to perform the repair of the structure. Members of the Idaho Transportation Department prepared the surface and applied the repair material. On site training and support was provided by Air Logistics Corporation.
Acknowledgment

This project was a good example of different organizations working as a team. AIR LOGISTICS CORPORATION acknowledges the job carried out by Mr. Berry Gwin of the IDAHO TRANSPORTATION DEPARTMENT for his vision in using advanced materials as an alternative technology on Idaho Bridges. Thanks also to Mr. Bill Kaufman, Construction Forman, IDAHO TRANSPORTATION DEPARTMENT and his crew for his support during the project.

Condition of the Bridge

The project consisted of two columns and a fill wall on the bridge over Moyie River. The original condition of the columns is pictured above. The columns are approximately 50 inches in diameter. As can be seen in the picture above, the bridge sub-structure is showing advanced concrete deterioration.

The deteriorated condition of the columns is primarily due to weathering, freeze / thaw cycling, and the use of salt in winter conditions. The two columns exhibited the same amount of degradation. The column pictured on Page 2 shows the “worst case” situation.
The diagram below shows the Aquawrap® wrapping pattern, which was used to mimic the tensile strength of a steel retrofit, proposed by the Idaho Transportation Department.

**PROPOSED DESIGN FOR FRP WRAP**

**AQUAWRAP® 22-71 System Components**

AQUAWRAP® 22-71 Concrete Repair System consists of four components: AQUAWRAP® 22-71 Structural Adhesive, AQUAWRAP® 22-71 Structural Prepreg Cloth, AQUAWRAP® 22-71 Veil Prepreg Cloth, and AQUAWRAP® Resin.

AQUAWRAP® 22-71 Structural Adhesive is a two part bonding material designed to produce a bond between the AQUAWRAP® 22-71 Structural Prepreg Cloth and the concrete substrate. AQUAWRAP® Resin is used between a cured layer and new layers of fresh fiberglass composite.
AQUAWRAP® 22-71 Structural Prepreg Cloth is the main component of the repair system. This is a woven roving material impregnated with a water cured resin system. The material comes packaged in moisture-tight packaging.

AQUAPREG STRUCTURAL CLOTH PACKAGING
AQUAWRAP® 22-71 Veil Prepreg Cloth is a tight-woven glass cloth impregnated with the same water cured resin system used in the AQUAWRAP® 22-71 Structural Prepreg Cloth. The material is also packaged in the same manner as the AQUAWRAP® 22-71 Structural Prepreg Cloth.

Structure Repair

The procedure for repairing the spalled surface is as follows:

- Remove spalled concrete from column.
- Clean concrete surface.
- Repair spalled areas with an approved mortar patch material.
- Use a propane torch to drive off any moisture from the surface of the repaired concrete.
- Apply AQUAWRAP® 22-71 Structural Adhesive.
- Apply the AQUAWRAP® 22-71 Structural Prepreg Cloth.
- Apply the AQUAWRAP® 22-71 Veil Prepreg Cloth.
- Allow the AQUAWRAP® 22-71 System to cure.
- Paint the surface with a system compatible paint.

The following photograph shows the column after the spalled areas have been repaired using mortar patch material approved by IDAHO TRANSPORTATION DEPARTMENT.
Apply the AQUAWRAP® 22-71 Structural Adhesive

After the column has been repaired with patching material, AQUAWRAP® 22-71 Structural Adhesive was applied to the surface using a short nap paint roller. It is important to remember to apply AQUAWRAP® 22-71 Structural Adhesive to small areas at a time. The AQUAWRAP® 22-71 Structural Adhesive must be allowed to “tack off” prior to applying the FRP material. If applied in too large an area the resin could cure prematurely necessitating an additional application of adhesive.

AQUAWRAP® 22-71 STRUCTURAL ADHESIVE APPLICATION
AQUAWRAP® 22-71 Structural Prepreg Cloth and AQUAWRAP® 22-71 Veil are applied in individual layers or may be wrapped in a spiral pattern. For spall repair the spiral pattern is preferred when full access to the column is available. In this case however, the layered method was used because the interior fill wall terminates the columns.

The AQUAWRAP® 22-71 system is water-cured composite system; water is sprayed on each layer as the material is applied. This is a confinement application without a full wrap-around, so AQUAWRAP® 22-71 Structural Adhesive was applied to the round as well as the flat surfaces.

The infill wall did not show significant deterioration. AQUAWRAP® 22-71 Veil was applied to this surface to protect it from any further wear and provide a good surface for painting. The AQUAWRAP® 22-71 Veil was also applied as stirrups to tie the horizontal wrap down and prevent it from de-bonding.
AQUAWRAP® 22-71 STRUCTURAL FABRIC APPLIED TO BULL NOSE

WATER SPRAYED BETWEEN LAYERS
The first day, three layers of cloth with water sprayed between the layers were applied to the bull nose sections of the columns. At the beginning of the second day, these three layers had cured. In order to bond the next layers to the cured AQUAWRAP® 22-71 a layer of AQUAWRAP® 22-71 resin is applied to the cured material. The material is allowed to become tacky and then the successive layers of the AQUAWRAP® materials are applied using the same techniques described above.

AQUAWRAP® RESIN APPLIED BETWEEN CURED FRP AND NEXT LAYERS

SUCCESSIVE LAYER ADDITION BEING SPRAYED WITH ACTIVATING WATER
During the installation of all the material on this project it was necessary to pay special attention to the inside corners between the column and infill wall. Prior to the material curing, a 2” X 4” X 36” piece of lumber was wrapped in plastic and was pressed into the corners and affixed to the structure using a Ram Set. The pressure applied by this method assured the adhesion in the tight bend of an inside radius corner. The piece of lumber was removed between applications. This method was used three times. Three layers were applied on day one, four layers on day two, three layers of AQUAWRAP® STRUCTURAL CLOTH and one layer of AQUAWRAP® VEIL on day 3.

During the installation on the bull nose sections of the column the excess material was trimmed before the material cured. This is the best time to trim the material. Once the material was cured, a power grinder was used to trim the top of the FRP and then the seam between the concrete and the FRP was filled with an epoxy caulking. The epoxy caulking will prevent water from getting between the FRP and concrete. All cracks on the top of the columns were injected with epoxy.
TRIMMING EXCESS MATERIAL

CUTTING OFF BOTTOM FLASH
During the installation of the 10 layers the ends of each layer were inset approximately $\frac{1}{2}$". This was done to prevent an area of stress concentration. When the material was cured the section was lightly sanded to smooth the area prior to installing the Veil stirrups used to hold the horizontal section in place. The tops of the columns were crack injected and painted to prevent water from getting into the column, preventing freeze / thaw problems.
One area of the underside of the stirrup had a void approximately 6” in diameter. The delaminated area was repaired prior to painting by injection of the area with a fast cure epoxy. A ¼” hole was drilled at the low side of the void and two ¼” holes were drilled at the high side of the void. The epoxy resin was then injected into the lower hole until the resin flowed out of the upper holes. The holes were sealed with tape while the epoxy cured. The tape was removed prior to painting.

Upon completion of all the sealing, injection, sanding and wiping down the structure was ready for painting.

A 1-½” X 1-½” stainless steel angle iron strip was permanently attached to each inside corner formed by the columns and in fill wall.

The paint chosen for this project was EDGE COAT manufactured by SCCI in Monrovia, CA. This paint is a urethane / acrylic paint filled with sand and recycled tires. The paint is very durable and has a high level of UV protection. Many transportation departments around the country use this paint.
STRUCTURE READY FOR PAINT

PAINT APPLIED BY HOPPER GUN
Labor and Labor Analysis

The man-hours used on this project are summarized in the table below. The staff size was 5 workers on all days except on 8-6-01 when 7 people were used.

<table>
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<th>Date/ Task</th>
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<th>7-24</th>
<th>7-24</th>
<th>7-26</th>
<th>7-30</th>
<th>7-31</th>
<th>8-1</th>
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<td>30</td>
<td>30</td>
<td>30</td>
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AIR LOGISTICS CORPORATION was the material supplier for this project. The materials supplied for the project were:

AQUAWRAP® 22-71 Structural Adhesive  
AQUAWRAP® 22-71 Structural Prepreg Cloth.  
AQUAWRAP® 22-71 Veil Prepreg Cloth.  
AQUAWRAP® 22-77 Resin

In addition to the materials supplied by AIR LOGISTICS, Idaho Transportation Department supplied the labor for the installation.

AIR LOGISTICS provided technical representation and onsite training.

The following chart gives a breakdown of the materials and their usage.

<table>
<thead>
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<th>MATERIALS</th>
<th>Rolls Used</th>
<th>Gallons Used</th>
<th>Square Footage</th>
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<tr>
<td>AQUAWRAP® 22-71 Structural Adhesive</td>
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<td>2½ 1-Gallon Kits (5 Gallons)</td>
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<td>AQUAWRAP® 22-71 Veil</td>
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<td>45 - 12’ rolls</td>
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<td>AQUAWRAP® 22-71 Structural Cloth</td>
<td>64 - 21’ rolls</td>
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<td>AQUAWRAP® Resin</td>
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<td>2 Gallons</td>
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<tr>
<td>Edge Coat Paint</td>
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<td>10 Gallons</td>
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</table>

Prior to the repair process, IDAHO TRANSPORTATION DEPARTMENT had the columns prepared for the wrap. This included rebuilding the surfaces of the column and bull-nose.
Tools Used

The following tools were used during the project:

Project plans
Safety gear
Hard hats
Safety glasses
Safety shoes
Vest with reflective markings
Water
MSDS and certificates of all materials
Generator
Mixing equipment for adhesive (drill and mixing blades)
Cutting tools / Grinding equipment
Neoprene latex gloves (XL)
Paint pails
Acetone
Squeegees with handles
Mixing buckets
Flat sticks to mix/scoop adhesive from buckets
Trowels to apply adhesive
Garden trowels to scoop adhesive from buckets
Scissors
Knives
Wire brushes
Rags
Extension cords
Tape measure
Garden sprayer
Propane weed torch
Ram Set
Paint Hopper Gun

SAFETY

Reiterate safety procedures to everyone. Assign people for each column: Mixer, Resin applicator, Adhesive, Safety officer/Supervisor/Quality assurance.

Safety meetings were held at the beginning of each shift. Each project leader was responsible for the safety of his crew.
The weather conditions for this job were ideal for the application of FRP Materials. This temperature range allows enough working time for the materials, although Aquawrap® is about as temperature insensitive as conventional concrete. In some cases there were reasons to partially remove a layer before cure occurred and the weather allowed this.

Anomalies Noted

During the installation there was an anomaly seen. The AQUAWRAP® Adhesive had a tendency to foam more than usual. This situation was subsequently corrected at the factory. It was found that there was a higher than average amount of moisture in one of the components. This level of water is what caused the foaming.

NOTE: Because of overnight moisture due to weather conditions a propane torch was used to drive off surface moisture from the bare concrete surfaces.

Application of the AQUAWRAP® Adhesive using a foam roller was not successful. The chopped glass in the “B” component stuck to the roller. The foam roller was discarded and conventional rollers were used.
CONCLUSION

The repair of the bridge over Moyie River was accomplished in a timely manner. There was little waste of material and time. The process of repair using FRP has been demonstrated other times in Idaho, each time increasing the knowledge base for the introduction of this new technology.

In this case, the viability of composites from a constructability standpoint has been successfully demonstrated. In this particular application, the use of the water-cured factory-prepreg material proved to be an ideal and cost effective solution. The quality of the impregnation was improved from the typical wet lay-up. The impregnation of the fabric was complete and there was no evidence of dry fibers or curing problems. The impregnation of the fabric at the factory in a controlled environment provides the consistent quality required in these types of applications of composite materials.

The mess, equipment and additional labor associated with field impregnation were eliminated, allowing the crew to focus their efforts on the application itself.

By using this composite system, road closure was held to a minimum. Only a partial road closure was required for the off loading of supplies and equipment. No heavy equipment was used for this repair and because this is a NAFTA highway, road closures would have been detrimental to the trucking industries using this important highway. The equipment used to place and install a steel encasement or to complete a concrete replacement support structure may have necessitated complete road closure and would probably have been intolerable without bypass routes. This is one of those places where a composite solution really shows its best qualities.

The Aquawrap® 22-71 system proved to be installer and environmentally friendly in this especially environmentally sensitive location. There are very few options in the repair field when dealing with watershed locations. Aquawrap® has proven to be one of those rare options. Aquawrap® is ANSI/NSF approved for contact with potable water.